Space Weather Technical Forecast

Issued on Thursday, 01 December 2022 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/Minor Storm intervals day 1 (1st). Chance of M-flares. Active high energy electron fluence. CME arrival possible late day 3 or day 4 (3rd or 4th), but low confidence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with a long period M1.0 flare observed from AR3152 Cro/Beta peaking at 01/0721 UTC. A few C-class flares have also been observed. AR3152 is a small sunspot region in the northwest, with no significant growth observed. There are two further numbered regions. AR3153 Dkc/Beta is the most complex region, however this is current very close to the southeast limb, with the current analysis uncertain. There is the potential for this to change as a trailer region also rotates on, and any foreshortening reduces, increasing confidence the polarity of the leader spot. AR3154 Cai/Beta has also exhibited slow growth in the southern centre disc, but remains small and currently stable. A further small unnumbered Bxo/Beta region has also emerged on the northeast disc, whilst a further sunspot is rotating on the northeast (Perhaps Hsx/alpha, but too close to the limb to be certain). A moderately fast CME was observed from the M1.0 flare of AR3152, but is still under analysis.

Solar Wind / Geomagnetic Activity: The solar wind as measured by ACE and DSCOVR at L1, exhibited fast wind conditions due to the HSS of CH49 and CH52. Wind speeds have been Elevated to Strong, varying between 550-700 km/s. Density declined from slightly above average to around average. The total IMF strength, Bt, was mostly Moderate, 10-12 nT, but declined to be weak at below 7nT from 01/0945 UTC. The north-south component, Bz, oscillated between +11 nT and -10 nT. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Unsettled to Active with two periods of G1/Minor geomagnetic storms (30/1800-2100 UTC and 01/0300-0600 UTC).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES-16 has remained at Background levels. High energy electron flux (greater than 2MeV) at GOES-16 was initially at high levels, peaking at 9440 pfu at 30/1500 UTC, before dropping sharply after 30/1800 UTC to be Moderate thereafter. The associated 24 hour Fluence was above the Active (1e8 integrated pfu) threshold during the period. Observed fluence at 01/0000 UTC was 1.88e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be Low, but with a chance of rising to Moderate with an ongoing potential for M-flares, primarily from AR3153 in the southeast.

Solar Wind / Geomagnetic Activity: Slow CME arrivals are possible, mainly early day 4 (4th), due to a filament eruption on the 29th, although confidence is low with the timing. The CME from the M1-flare on the 1st has yet to be fully assessed. Otherwise, ongoing fast winds from CH49/+ and CH52/+ are expected to gradually decline through the period. Unsettled to Active geomagnetic conditions, with an ongoing chance of further G1/Minor storm intervals on day 1 (1st) will ease to Quiet to Unsettled, with a chance of Active intervals by day 3 (3rd). There is a chance of further isolated G1/Minor storm intervals from any CME arrival day 4 (4th).

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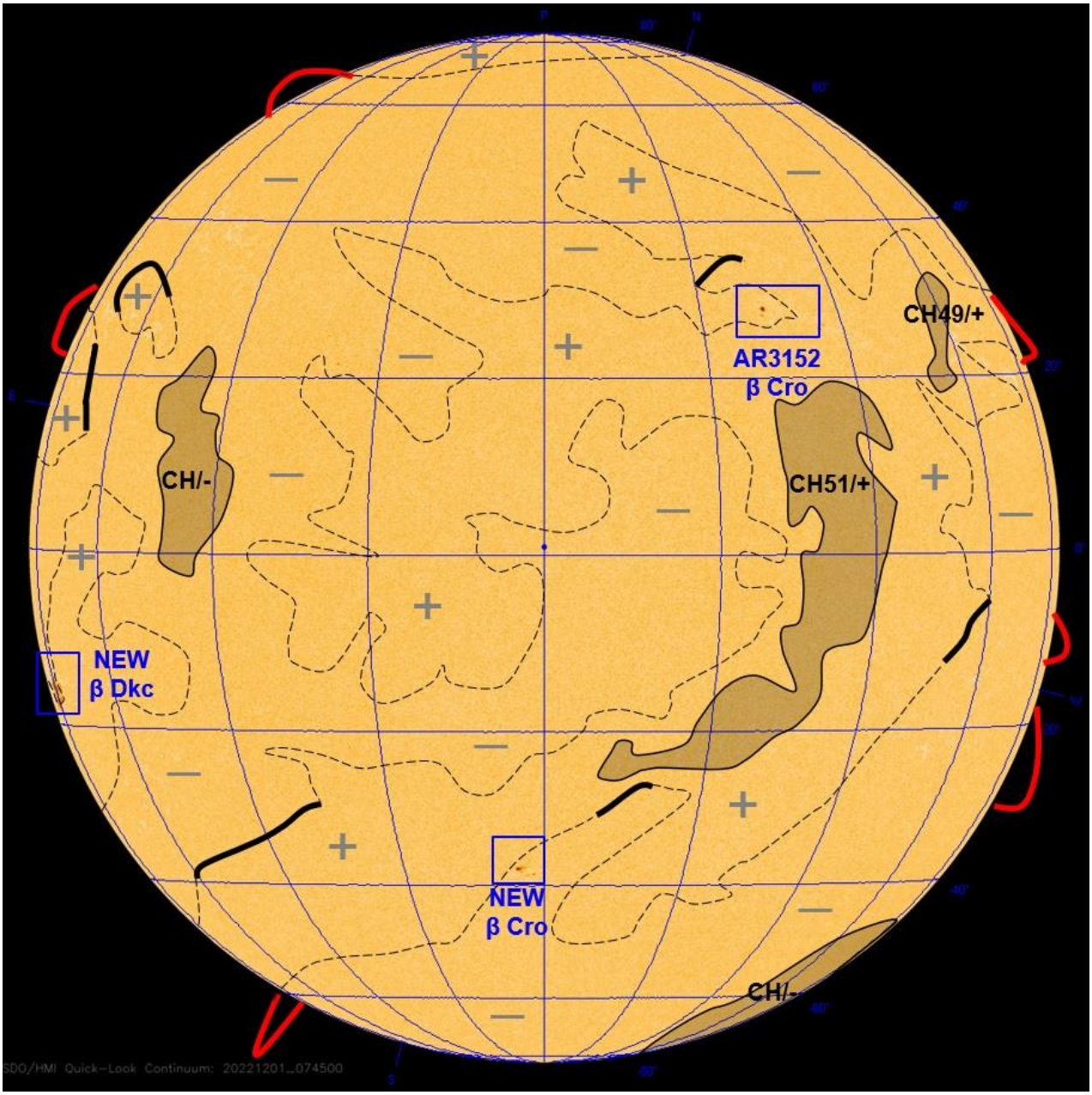
Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) at GEO, as observed by GOES16, is currently at background levels and is expected to remain at this level throughout. High energy electron flux (greater than 2 MeV), as observed by GOES16, is expected to rise again as the HSS wanes, likely above High by day 2 (2nd). Fluence levels are currently above the Active (1e8 integrated pfu) fluence threshold, but likely to decline below this level briefly, before rising above again day 2 (2nd).

Figure 1. Solar Analysis Valid 01/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A filament eruption on 29 Nov, and its associated CMEs have been assessed as slow, but with the possibility of Earth-directed components, although this is low confidence. Any arrival is most likely to occur early day 4 (4th), perhaps very late day 3 (3rd). The CME from the M1 flare of AR3152 at 01/0721 UTC has yet to be fully assessed.

Ongoing fast wind environment is expected to continue day 1 (1st), due to the high speed streams (HSS) of CH49 and CH52. Current elevated solar winds of around 550-600 km/s are forecast to only gradually fade through the period, with MOSWOC enlil indicating a slow decline to around 450 km/s by the end of day 3 (3rd). 27-day persistence suggests a similar gradual decline, albeit slightly faster, however CH52 is a larger feature on this occasion giving support to the forecast by the enlil model.

Unsettled to Active geomagnetic conditions, with an ongoing likelihood of further G1/Minor storm intervals on day 1 (1st) will ease to Quiet to Unsettled, with a chance of Active intervals by day 3. Any potential CME arrival, either later day 3 or day 4 (3rd or 4th) will bring the chance of further isolated G1/Minor storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	70	20	10	30
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/1246	Partial	Filament	SE	300 km/s	04/0600 +/-9 hours	Limited shock 2nd part of CME Low confidence
30/0730	Partial	Filament	SE	320 km/s	04/0600 +/-9 hours	Limited shock 1st part of CME Low confidence
01/1211	Partial	M1.0 of AR3152 @ 01/0721	NW	780 km/s	Unknown	Awaiting analysis. Possible glance.

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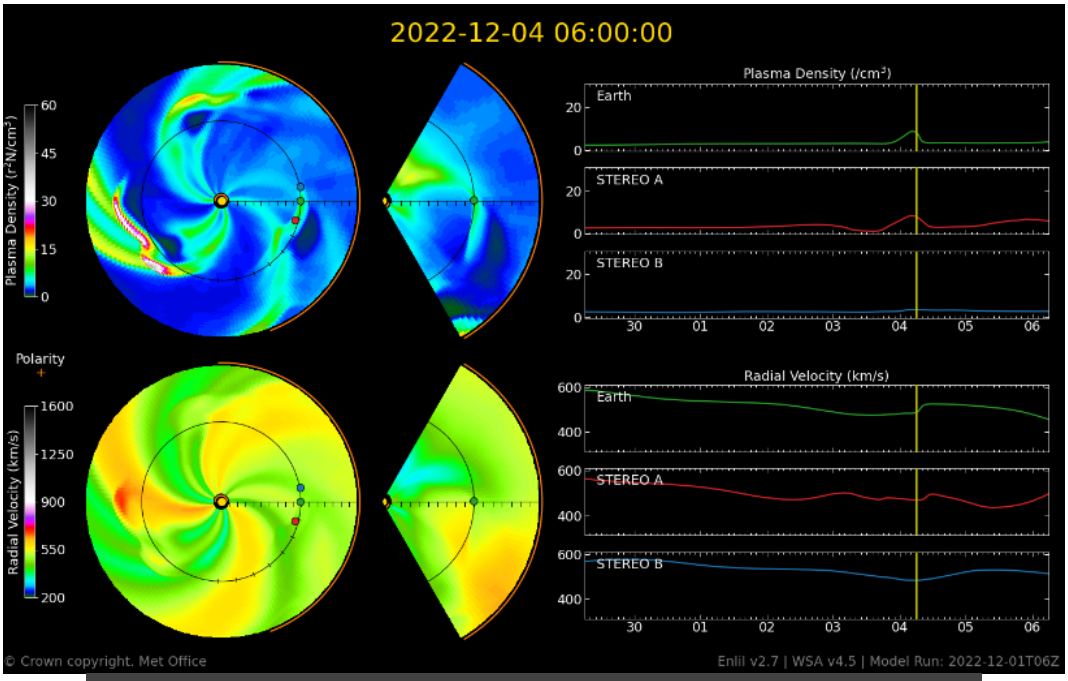
Figure 2a: ENLIL showing declining fast winds and CME arrival with ensemble. (3rd CME not yet included)



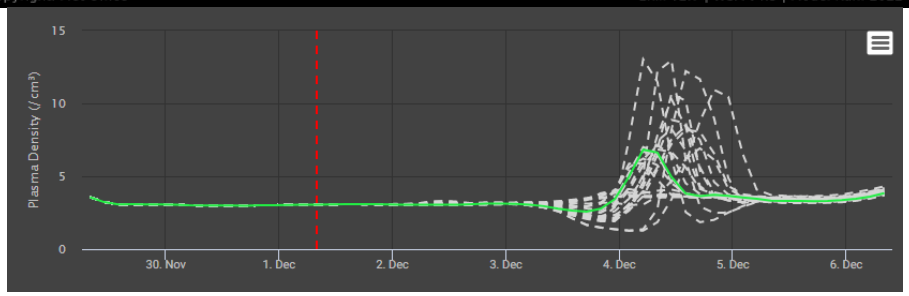
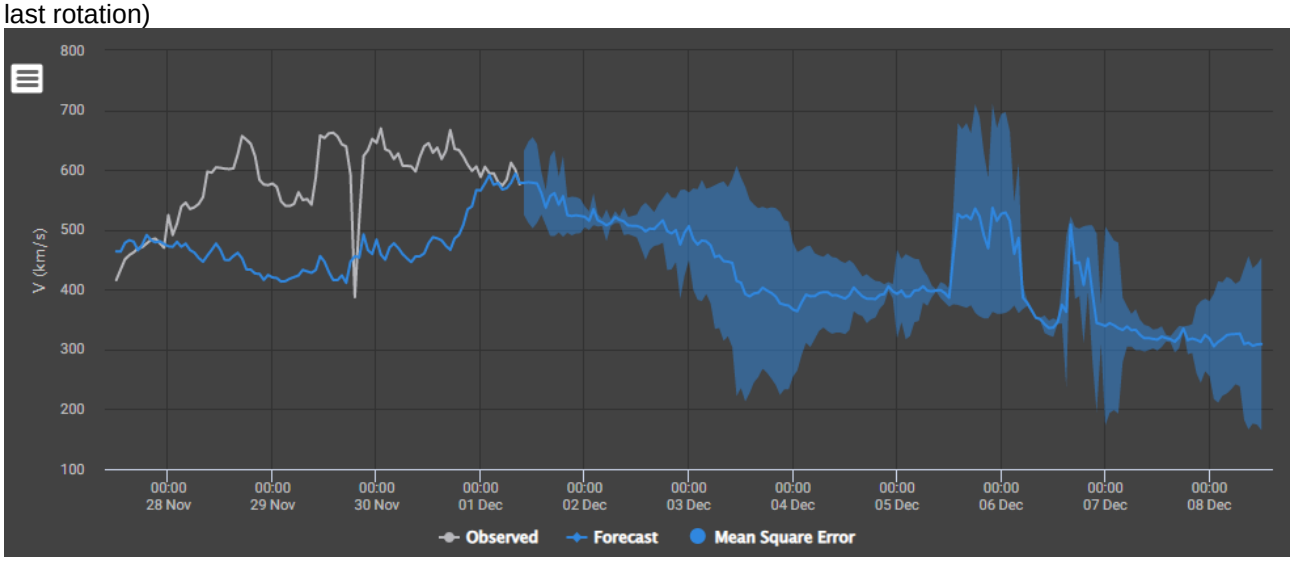


Figure 2b: Solar Wind persistence Model: Gradual decline indicated (enhancement on 5th due to CME on last rotation)



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Radio Blackouts - X-Ray Flares:

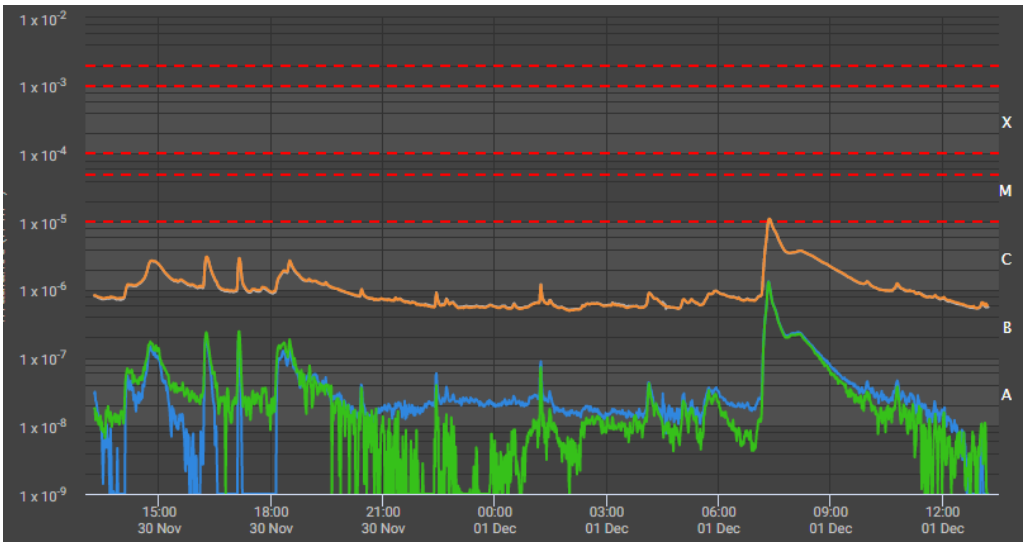
Low Activity is forecast to continue, but with a chance of rising to Moderate at times through the period. There is also a very slight chance of activity rising to Strong, however this will be reevaluated as new sunspots rotate into a clearer view.

The main source of this potential activity is newly numbered AR3153 rotating over the southeast limb. This region has currently been assessed as Dkc/beta, but perhaps comprises of a large leader spot, with a potential mixed polarity, followed by a further trailer which is only just coming into view. Although this is currently impossible to confidently ascertain at this stage. The polarities across the region also remain low confidence, but do have the potential for complexity. Furthermore, another new region is expected to soon rotate onto the northeast disk, with a bright area visible on STEREO A euvi, however this is also low confidence.

There are three other regions on the disc. AR3152 Cro/Beta is a small simple region, and whilst the source of the recent M1.0 flare, further significant flaring is unlikely. AR3154 Cai/Beta in the south-centre disc has been slowly growing with some flux emergence, but remains relatively simple. A new Bxo/Beta region has also emerged in the northeast, but is unnumbered, small and stable.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	25	25	25	25
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/17 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) at GEO, as observed by GOES16, is currently at background levels and is expected to remain at this level throughout the period.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2 MeV), as observed by GOES16, was at high levels before dropping sharply after 30/1800 UTC. This was due to increased geomagnetic activity associated with the ongoing HSS from CH49 and then CH51. This HSS is also likely to be compressing the main radiation belt inside the GEO orbit. Further charging is likely to be taking place from this HSS, and as it wanes, an increase in electron flux is likely.

Fluence levels are currently above the Active (1e8 integrated pfu) fluence threshold, but are likely to have peaked in the short term with a brief declining trend, perhaps below Active briefly, before soon rising back above into day 2 (2nd). Fluence levels are then likely to increase in the following days as the HSS wanes. Confidence in an increasing trend is reasonable, but low for the timing of the increase. REFM is forecasting above Active through the next 3 days, although forecast values may be too high especially in the short term.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	80	90	90
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	2	2

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Figure 4: GOES-16 >2MeV Electron Flux and Fluence with REFM

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